Before the

FEDERAL COMMUNICATIONS COMMISSION
Washington, DC. 20554

In the Matter of	)	
	)	
Mitigation of Orbital Debris	)	**IB Docket No. 02-54**
	)	
	)	
	)	

To: The Commission

COMMENTS of Nickolaus E. Leggett
N3NL Amateur Radio Operator

The following are comments from Nickolaus E. Leggett, an amateur radio operator, inventor, and a certified electronics technician. My comments are primarily directed at amateur radio satellites. However many of my comments can apply to commercial communications satellites as well.

Innovative Amateur Radio Satellites

The Commission can structure the debris mitigation rules so that they will encourage the design and construction of amateur radio satellites that reduce their own debris potential while at the same time demonstrating new satellite systems.

One way to do this is to allow amateur satellites that are continuously operating within a storage or disposal orbit to avoid having to meet any other debris mitigation standards. These amateur satellites would cruise within the storage orbit "junkyard" while they are providing active communications service to amateur radio operators around the World.

In this approach, amateur satellites operating in the following orbits would be exempt from debris mitigation regulations:

- Below 600 km apogee
- 2000 km perigee to 19,700 km apogee
- 20,700 km perigee to 35,300 km apogee
- Above 36,100 km perigee (including stations installed on the Lunar surface)
- Earth-escape trajectories (including stations installed on other planetary bodies such as Mars)

Each of these orbits provides for the automatic safe disposal of the amateur radio satellite. This disposal would not depend on the reliable operation of an active propulsion system years after the satellite was launched. This would provide fail-safe operation without impact on the highly used portions of Earth orbital space: high Low Earth Orbit, semi-synchronous orbit, and geosynchronous orbit.

In addition, these amateur satellites would pioneer the use of the storage orbits for something else in addition to storage of dead satellites. Amateur radio operators are good at discovering constructive uses for apparently "useless" resources such as this. Each amateur radio satellite will be able to cruise for years in these orbits without impacting serious debris. All that time they can be relaying signals between terrestrial amateur stations that are equipped with directional antennas and a computerized ephemeris of the satellite's orbit.

Some of these orbits are in areas with high ionizing radiation levels. This radiation can be damaging to the satellite's electronics. Amateurs can overcome this problem by experimenting with shielding systems, redundant electronics, or natural vacuum electronics. Natural vacuum electronics would use thermionic emission valves (small or microscopic vacuum tubes without the tubular enclosures) that would be highly resistant to radiation damage (Reference 1)

High Orbits in the Low Earth Orbit Range

Paragraph 56 of the Notice of Proposed Rule Making discusses a requirement that satellites operating in circular orbits from 1000 to 1600 km would be required to reduce their orbit to an altitude of 600 kilometers at the end of the satellite's useful life (or raise the orbit above 2000 kilometers). At 600 km, the atmospheric drag would remove the satellite within 25 years. Above 2000 kilometers the satellite is in a storage orbit. This end-of-life maneuvering requirement imposes a very large penalty on small satellites that traditionally are not equipped with propulsion systems at all. From the start of space flight, many satellites without propulsion systems have been launched. Examples include the early Sputnik and Vanguard satellites all the way through most of the Orbital Satellites Carrying Amateur Radio (OSCAR satellites). Almost by definition a modern microsat in the altitude range of 1000 to 1600 km would be outlawed by this requirement.

This problem could be avoided by providing an exemption from this rule for amateur satellites. This exemption would apply for a fixed period of time such as ten years. During this period, amateur satellites without propulsion systems could be launched, and research could be conducted on cost-effective propulsion means for small amateur radio satellites. At the end of the exemption period, amateur radio satellites launched to this altitude range would have to be equipped with some type of propulsion system for disposing of the satellite. Establishing this exemption for a period of ten years would have a very limited impact on the space environment since only a few LEO amateur radio satellites are launched each year.

Maintaining Orbital Parameters

Paragraph 49 of the NPRM discusses a requirement that non-geostationary satellites establish and <u>maintain</u> specific orbit parameters. The term <u>maintain</u> implies that each

satellite must be equipped with an active onboard propulsion system that would be used periodically to adjust the orbit back to the established parameters. This is an even more demanding requirement than a propulsion requirement for final disposal of the satellite. This requirement could block small simple satellites in any orbit. There is really a question if such a draconian requirement is needed to prevent space collisions. After all, orbital space is quite large in volume and the total number of amateur radio satellites ever launched is quite small.

Manned Space Flight Scenarios

One of the major arguments for orbital debris mitigation is the protection of manned space flights from disastrous impacts of space debris. The major aspect here is the anticipated frequency of the manned space flights. Manned space flights are fairly frequent and routine in low earth orbit. New participants such as the Peoples' Republic of China and private firms will join the nations currently flying manned vehicles in LEO. In addition, the International Space Station (ISS) is permanently manned. This in itself justifies a serious effort on orbital debris mitigation.

However, a different situation holds beyond LEO. No manned space flights beyond low earth orbit are currently planned. Eventually, the following types of manned space flights are expected:

- Additional expeditions to the Moon
- Establishment and supply of a manned Lunar base
- An expedition to Mars

These flights will be quite rare activities unless new and radically more economical space propulsion and transportation systems are developed. The current cost of deep space

transportation is $10,000 and up per pound of payload. If this cost were slashed to $50 to $100 per pound of payload, manned space flight beyond LEO would probably boom with many more flights being conducted. Just the demand for scientific and tourist flights would be intense.

To be prudent, the Commission should act to mitigate orbital debris that could greatly inhibit the future of manned space flight as well as being a threat to unmanned satellite resources. However, the steps taken should be moderate. There is sufficient time available to study and experiment with options.

Future Amateur Radio Satellites

Eventually, amateur radio satellites will be delivered into LEO as secondary payloads as they are now. Onboard ion propulsion or solar sail technology will be deployed to gradually move the satellite into a storage orbit where the satellite will continue operating. This will be an exciting and worthwhile challenge for amateur radio, but sufficient time must be provided for the development of these significantly more advanced satellites.

Recommended Actions

The Commission should exempt amateur radio satellites from any requirements for debris mitigation for a period of ten years. After that period of time has expired, amateur radio satellites would be subject to debris mitigation standards. Amateur radio satellites operating within storage orbits or other safe orbits should be permanently exempt from debris mitigation standards and requirements.

Respectfully submitted,

Nickolaus E. Leggett
Amateur Radio N3NL
1432 Northgate Square, Apt. 2A
Reston, VA 20190-3748
(703) 709-0752
nleggett@earthlink.net

Date: April 3, 2002

(1) Leggett, Nickolaus E., "Natural Vacuum Electronics", Vision-21: Space Travel for the Next Millennium, NASA Lewis Research Center, Cleveland Ohio, April 3-4, 1990, NASA Conference Publication 10059, pp. 477-480 (Report No. NASA CP-10059)

"Natural vacuum electronics use this basic vacuum tube flow without the need for the vacuum sustaining enclosure. The cathode and anode are directly exposed to the ambient environment of space."